Viscoelastic Effects in Phase Separation in Polymer Solutions and Blends

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Viscoelasticity in early stage spinodal decomposition: We first examine how viscoelasticity affects early stage spinodal decomposition in polymer solutions and blends when fluctuations of the stress and the composition are coupled in dynamics [1]. The coupling is increased with increasing asymmetry between the two components. We introduce a long viscoelastic length ξ_{ve} within which the stress relaxation governs the composition relaxation. It can be of the order of the tube length in the reptation theory in strongly asymmetric polymer blends. For shallow quenching phase separation proceeds on time scales slower than the stress relaxation time τ and the kinetic coefficient depends on the wave number q as q^{-2} for $q\xi_{ve} > 1$ [2] On the other hand, for deep quenching phase separation takes place as in gels on time scales faster than τ . We describe the crossover between these two cases by assuming a single stress relaxation time.

Network domain structure in deeply quenched polymer solutions: We secondly discuss formation of sponge-like network structures composed of thin polymer-rich regions in late stage spinodal decomposition of deeply quenched polymer solutions. It has been observed particularly in detail by Tanaka [3]. We solve a viscoelastic model of polymer solutions in two dimensions to demonstrate that polymer-rich regions can form a sponge-like network in deeply quenched cases [4]. In late stages the velocity field is suppressed because the network supports stress and is rigid. As a result the domain size grows as $t^{1/3}$. In an early stage the polymer-rich regions are shrunken due to desorption of solvent, whereas in late stages they are elastically expanded perpendicularly to the interface in regions with relatively small curvature. The viscoelastic stress then cancels the stress due to the surface tension and stabilizes the network structure for a long time.

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